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WS 107A-1 FLIGHT TEST WORKING GROUP

FLIGHT TEST REPORT

ATLAS MISSILE 13E

13 MARCH 1961

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GENERAL DYNAMICS CORPORATION

SECRET

FOREWORD

This report has been prepared to present preliminary information relative to the flight of Atlas Missile No. 13E. The information presented is based on visual observation and data evaluation to the extent permitted by time limitations. It should be considered as preliminary only and the final reports on this flight referenced for further information. The technical content has been prepared and jointly agreed upon by members of the WS 107A-1 Flight Test Working Group.

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SUMMARY

Atlas Missile 13E, the fifth "E" Series missile to be flight tested, was launched from AMR, Complex 13, at 2317 EST, on 13 March 1961. The planned range for this flight was 7863 nautical miles with impact in the Indian Ocean. This range was not achieved due to premature sustainer engine shutdown as a result of fuel depletion. Fuel depletion was caused by failure of the sustainer main fuel valve to enter control during engine start and the valve apparently remained at the full open position throughout the flight. The exact cause of the failure of the valve to respond to the Error Demodulator Output signal cannot be determined from available instrumentation. However, failure of any of several components in the Propellant Utilization System and in the hydraulic control package not monitored by instrumentation, or loss of continuity between the two assemblies could have resulted in the above occurrence.

An anomaly was noted in the Missile Electrical System performance. Although adequate power was supplied throughout powered flight, a decrease in d-c voltage started at 175 seconds. Voltage decreased from 29 vdc to 25 vdc at re-entry vehicle separation and further decreased to 6.5 vdc at 650 seconds. This is under investigation.

The Mod III instrumentation system tracked on a side lobe from approximately 40 to 104 seconds, and characteristics were similar to track performance on Missile 9E. Satisfactory information was obtained after this time through sustainer shutdown.

All other systems operated normally throughout powered flight.

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FLIGHT TEST OBJECTIVES

The primary purposes of this flight were to evaluate E Series missile system performance, ARMA guidance system accuracy, and re-entry vehicle performance (heating, loading and ablation) at maximum R and D range.

Early termination of the flight precluded complete satisfaction of these objectives. Detailed objectives are listed on the following pages along with applicable comments relative to the degree of satisfaction.

OBJECTIVES	ORDER	YES	NO	PART	COMMENT
1 - First Order 2 - Second Order 3 - Third Order					
Weapons System Objectives					
1. Obtain data on the repeatability of performance of all missile systems and associate GSE.	2			X	
2. Evaluate MA-3 Propulsion System performance	2			X	
3. Evaluate ARMA Inertial Guidance System performance and accuracy.	1			X	
4. Evaluate Flight Control System performance.	1			X	
5. Evaluate Re-entry Vehicle performance (heating, loading and ablation) at maximum R & D range.	1		X		
6. Demonstrate the performance of the arming and fuzing system.	1		X		
7. Demonstrate missile systems performance at maximum R & D range.	1		X		
8. Evaluate the performance of the Hydraulic Systems.	2			X	
9. Obtain data on missile base heating.	3	X			

OBJECTIVES	ORDER	YES	NO	PART	COMMENT
Non-Weapon System					
1. Obtain Data on performance of the airborne instrumentation and range safety systems. (GE Mod IIIE and Tlm).	3			X	
2. Obtain Data on Strobe Optical Beacon System performance.	3		X		
3. Obtain Data on penetration characteristics during re-entry phase.	3		X		

FORM A1336

FLIGHT TRAJECTORY

Atlas Missile 13E was the first "E" Series missile planned for a long range flight of 7863 nautical miles. This range was not achieved due to a premature shutdown of the sustainer engine. The trajectory of the missile appeared to be very close to nominal prior to sustainer shutdown.

SYSTEM PERFORMANCE

AIRFRAME

Missile structural integrity was maintained throughout powered flight and well beyond re-entry vehicle separation. Satisfactory booster separation was indicated by measurement M 143 D, Booster Section Separation, and satisfactory re-entry vehicle separation was indicated by flight control data.

All thrust section temperatures appeared satisfactory and well within normal range. Missile 13E carried three calorimeters installed on the aft side of the heat shield in the area of the Quad III/IV disconnect panel to measure total and convective heat impingement from the engine exhaust. The highest temperature recorded by these calorimeters was 610°F by measurement A 412 T, Black Calorimeter in Qd IV. Maximum total heat impingement recorded was 69,000 BTU/Ft^2 HR at approximately 60 seconds. The calorimeter data are very sensitive to methods of reduction and the above value is approximate and preliminary only.

Missile 13E carried five measurements to determine temperature environment in the V2 fairing area. The maximum temperature recorded was 470°F at approximately 109 seconds by measurement A 2 T, V2 Clamshell Ambient. This measurement also recorded the maximum temperature in the V2 fairing area on Missile 9E at approximately the same time; however, the temperature during that flight reached 680°F. Temperature at the V2 conduit did not exceed 250°F while the V2 Servo Electrical Connection temperature did not rise above 185°F.

PROPULSION SYSTEM

Booster engine parameters indicated satisfactory engine performance throughout booster phase. The sustainer engine shut down prematurely at 252 seconds due to fuel depletion. All sustainer engine data with the exception of PU valve angle data, indicated proper performance levels until time of shutdown. PU valve angle data indicated the PU valve apparently did not go into control and remained at an angle greater than 65 degrees (outside the information band limit) throughout powered flight.

The cause of the above occurrence is not known at this time; however, a discussion of suspect areas is presented in the Propellant Utilization System Section of this report.

Engine start characteristics appeared normal and the engine parameters reflected proper performance levels up to sustainer shutdown. The sustainer delay start time was 550 milliseconds.

Sustainer engine parameters at shutdown properly reflected fuel depletion with SGG combustor temperature increasing rapidly and the turbopump overspeeding. After shutdown the PU valve went closed and the HS valve went to the full open position

Vernier engine solo operation after sustainer shutdown was normal for 27 seconds. After this time, chamber pressure data indicated a slow pressure decay resulting from solo propellant depletion. Propellant depletion was also reflected by a decrease in the vernier propellant tank pressures.

The RCC accelerometers monitoring booster engine vibrations up to 15 feet of rise indicated slightly greater vibration than has been experienced on previous "E" Series flights. Vibration levels recorded during this time were between 6 and 31 G's RMS @ 740 cps for B1 and between 10 and 32 G's RMS @ 720 cps for B2. The B2 accelerometer indicated a burst of 60 G's RMS @ 800 cps and above at 0.39 seconds during main propellant ignition. The frequency of all vibration was below the RCC low band-pass filter limit of 960 cps.

Missile axial thrust levels during flight were as follows:

Engine	Units	After Liftoff	Prior To BCO	Prior To Sustainer Shutdown	Prior To Vernier Shutdown
Booster No. 1	lbs	165,000	196,900	---	---
Booster No. 2	lbs	165,400	197,100	---	---

Engine	Units	After Liftoff	Prior To BCO	Prior To Sustainer Shutdown	Prior To Vernier Shutdown
Sustainer	lbs	58,200	84,400	82,000	---
Vernier No. 1	lbs	810	980	740	630
Vernier No. 2	lbs	810	970	770	630

Equations used for computing thrust were:

Boosters $F = (1.600 - \frac{P_o}{P_c} \epsilon) P_c A_t$

Sustainer $F = (1.749 - \frac{P_o}{P_c} \epsilon) P_c A_t$

Verniers $F = (1.543 - \frac{P_o}{P_c} \epsilon) P_c A_t \cos \theta$

Where P_o = Ambient Pressure
P_c = Combustion chamber Pressure
ϵ = Expansion Ratio (Booster No. 1 = 7.94, Booster No. 2 = 7.93, Sustainer = 24.8, Verniers = 5)
A_t = Chamber Throat Area (Booster No. 1 = 205.1 in^2, Booster No. 2 = 205.3 in^2, Sustainer = 67.01 in^2, Verniers = 2.1 in^2)
θ = Angle of Vernier from the Missile Longitudinal Axis in the Pitch Plane.

PROPULSION SYSTEM TIME SLICE DATA

Measurement No.	Description	Units	Steady State Expected Values	L/L At Liftoff	After Liftoff	Prior To BCO	Prior To Sustainer Shutdown	Prior To Vernier Shutdown
P 155 P	B1 GG Combustor	psia	490	---	470	500	---	---
P 184 P	B2 GG Combustor	psia	490	---	470	490	---	---
P 713 T	B1 GG Combustor Temp	dgf	1100	---	997*	1044*	---	---
P 714 T	B2 GG Combustor Temp	dgf	1100	---	1067	1149	---	---
P 473 P	B1 Lo Pr Lube Oil Man	psia	110	---	116	98	---	---
P 279 P	B2 Lo Pr Lube Oil Man	psia	110	---	113	96	---	---
P 1020 T	B1 LO2 Pump Inlet Temp	dgf	-294	-287	---	---	---	---
P 1054 T	B2 LO2 Pump Inlet Temp	dgf	-294	-287	---	---	---	---
P 84 B	B1 Pump Speed	rpm	6100	---	6098	6236	---	---
P 83 B	B2 Pump Speed	rpm	6170	---	6084	6209	---	---
P 39 P	B1 Fuel Pump Disch	psia	835	---	810	850	---	---
P 38 P	B2 Fuel Pump Disch	psia	835	---	800	830	---	---
P 91 P	B1 LO2 Inj Man	psia	675	---	675	710	---	---
P 92 P	B2 LO2 Inj Man	psia	675	---	665	710	---	---
P 60 P	B1 Thrust Chm	psia	575	---	576	600	---	---

Measurement No.	Description	Units	Steady State Expected Value	L/L At Liftoff	After Liftoff	Prior To BCO	Prior To Sustainer Shutdown	Prior To Vernier Shutdown
P 59 P	B2 Thrust Chm	psia	575	---	576	600	---	---
P 1711 T	B1 Nacelle Ambient	dgf	30-120	46	---	---	---	---
P 1712 T	B2 Nacelle Ambient	dgf	30-120	61	---	---	---	---
Sustainer Engine								
P 337 P	SGG LO2 Inj Man	psia	850	---	860	860	830	---
P 709 T	SGG Combustor Temp	dgf	1100	---	1086	1084	1182	---
P 341 P	S Lube Oil Man	psia	600	---	675	675	660	---
P 56 P	S LO2 Pump Inlet	psia	---	---	71	115	61	27
P 530 T	S LO2 Pump Inlet Temp	dgf	-293	---	-295	-291	-291	-291
P 349 B	Sus Pump Speed	rpm	10,000	---	10,186	10,224	10,232	---
P 529 D	S Main LO2 Valve	deg	---	---	32.3	30.3	29.8	90.0
P 528 D	S Main Fuel Valve	deg	29.5	---	>64	>64	>64	<9.0
P 330 P	S Fuel Pump Disch	psia	1000	---	915	945	930	---
P 351 P	S LO2 Inj Man	psia	800	---	810	820	790	---
P 6 P	S Thrust Ch mber	psia	690	---	705	720	700	---
P 1710 T	S Eng Environment	dgf	30-120	92	---	---	---	---
Vernier Engines								
P 1474 P	Vern Ctl Press Reg Out	psia	605	592	---	---	---	---

Measurement No.	Description	Units	Steady State Expected Values	L/O Lift	After Liftoff	Prior To BCO	Prior To Sustainer Shutdown	Prior To Vernier Shutdown
P 30 P	Vernier LO2 Tank	psia	585	---	27	54	675	580
P 27 P	Vernier Fuel Tank	psia	585	---	113	656	661	596
P 28 P	V1 Thrust Chamber	psia	340/300	---	336	348	356	302
P 29 P	V2 Thrust Chamber	psia	340/300	---	335	347	367	303
Miscellaneous								
P 1325 T	Eng Comb Amb	dgf	---	94	---	---	---	---
P 671 T	Thrust Section Ambient	dgf	---	---	86	94	110	133

NOTE: Steady-state expected values are based on Rocketdyne Engine Acceptance Test Data. Individual parameters will vary from engine to engine.

* Qualitative only - segment spiked.

PNEUMATIC SYSTEM

Performance of the Pneumatic System was satisfactory. Missile 13E was equipped with "Stratos" pneumatic regulators which operated satisfactorily. Missile tank and engine control bottle pressures were normal prior to engine start and liftoff and were satisfactorily maintained throughout powered flight.

Tank Pressurization System

LO2 and fuel tank pressures were satisfactorily maintained throughout the flight. Fuel tank pressure decayed to 48.8 psia at sustainer engine shutdown and remained at this level for the duration of flight. LO2 pressure regulator inlet temperature appeared normal indicating a maximum temperature of 365°F at booster cutoff. Booster tank helium bottle pressure and temperature showed normal variations throughout booster phase.

Engine Control Pressurization System

Sustainer control helium bottle pressure was adequate for engine functions throughout powered flight. Bottle pressure decayed from 3023 psia at liftoff to 2774 psia at sustainer engine shutdown. Pressure decay during vernier solo appeared normal but decay continued after vernier shutdown reaching zero psia at approximately 308 seconds. Complete depletion of the control bottle is attributed to the vernier engine valves remaining open after vernier shutdown. Specific values taken from landline and telemetry records are presented on the following page.

PNEUMATIC SYSTEM TIME SLICE DATA

Measurement No.	Description	Units	L/L	After Liftoff	Prior To BCO	Prior To Sustainer Shutdown
F 1001 P	LO2 Tank Helium	psia	37.3	37.6	25.2	24.4
F 1003 P	Fuel Tank Helium	psia	73.9	73.9	61.3	48.8
F 1145 P	S Ctl He Bottle Disch	psia	3023	2965	2826	2774
F 1246 P	B Tank He Btl Hi	psia	3018	2802	837	---
F 1194 P	Facility GN2 Supply	psia	1834	---	---	---
F 1047 P	PCU Fuel Sensor Line	psia	73.6	---	---	---
F1050 P	PCU LO2 Sensor Line	psia	43.3	---	---	---
F 115 T	LO2 Press Reg Inlet	dgf	---	186	363	---
F 247 T	B Tank He Bottle	dgf	---	-328	-376	---

HYDRAULIC SYSTEMS

Performance of the Hydraulic Systems was satisfactory. Booster and sustainer system pressures remained at normal levels throughout engine operation. There was no evidence of the recurring sustainer hydraulic problem which was evident on Missiles 3E and 4E. Normal system pressures were maintained until engine shutdown. Vernier solo accumulator pressure lasted approximately 17 seconds after sustainer engine shutdown, bottoming out at 1050 psia.

Hydraulic system temperatures, measured in the Quad I/II disconnect panel, were similar to those recorded on Missile 8E. H 317 T, Rise-Off Disconnect Panel-Booster Inlet, indicated a maximum temperature of 315°F at approximately 68 seconds, while H 316 T, Rise-Off Disconnect Panel-Sustainer Inlet, recorded a maximum temperature of only 50°F at approximately 85 seconds. As on Missiles 8E and 9E there was an unexplained temperature difference between these two measurements although they were located adjacent to each other in the Quad I/II disconnect panel.

The sustainer hydraulic low pressure measurements generally indicated satisfactory pressure; however, measurement H 219 P, Sustainer Tank Reservoir Gas, indicated a pressure 20 to 30 psi lower than H 185 P, Sustainer Hydraulic Pump Inlet, and H 212 P, Vernier Return. No explanation for this is evident at this time and further investigation will be needed to determine the validity of these measurements.

The microswitch measurement, H 227 X, monitoring sustainer hydraulic system reservoir piston movement, appeared to operate satisfactorily indicating the piston was bottomed on the gas side prior to oil evacuate and that the piston was free after oil evacuate and during flight.

Only one of the break-wire measurements indicated activation throughout the flight. This occurred at sustainer engine shutdown when, H 388 X, Engine Control to Pressure Line, dropped from 100 percent to zero percent. An unusual transient was recorded on the data from the three break-wire measurements between liftoff and approximately 18 seconds. However, the transient was not a "broken-wire" indication, but may have been caused by a temporary shift in the independent 5 vdc measurement excitation power supply.

HYDRAULIC SYSTEMS TIME SLICE DATA

Measurement No.	Description	Units	After Liftoff	Prior To BCO	Prior To Sustainer Shutdown
H 33 P	B1 Hydraulic Accum.	psia	3045	3010	---
H 224 P	B Hyd Lo Press Sys	psia	78	72	---
H 225 P	B Tk Resvr Gas	psia	74	68	---
H 52 P	Sus Hyd Accumulator	psia	3112	3077	3041
H 130 P	Sus Hyd Pump Disch	psia	3042	3042	3020
H 140 P	Sus/Vern Hyd Press	psia	3081	3063	3115
H 19[illegible] P	Sus Hi Press To Man	psia	3008	3008	3008
H 398 P	NAA Hyd Accum Gas	psia	*	*	*
H 219 P	Sus Tk Resvr Gas	psia	75	69	68
H 185 P	Sus Hyd Pump Inlet	psia	94	99	94
H 212 P	Vernier Return	psia	92	94	90
H 316 T	ROD Panel Sus In	dgf	86	172	---
H 317 T	ROD Panel B In	dgf	67	212	---

* Instrumentation Malfunction

MISSILE ELECTRICAL SYSTEM

Performance of the Missile Electrical System was satisfactory throughout powered flight. Telemetered data indicated that sufficient a-c and d-c electrical power were supplied during that period. All system parameters remained within specifications until nominal end of powered flight.

Missile main battery voltage remained steady at 29.1 vdc until 177 seconds. At this time, a gradual decrease in voltage began and by 339 seconds voltage had dropped to 25 volts. At 450 seconds, an increase in decay rate was noted and voltage decreased to 6.6 volts at 650 seconds. Inverter phase A and phase C voltages remained between 115.2 and 116.7 vac and 114.7 and 116.4 vac, respectively, over the time interval from engine start to beyond 400 seconds.

Inverter frequency remained between 401.2 and 405.4 cps during this interval. Inverter frequency transients occurred at engine start, booster cutoff, sustainer shutdown, and retro-rocket firing.

The following transients occurred during the flight.

Time	Observation
15 secs.	A 0.4 volt increase in phase C voltage over a 3 second interval.
78.6 secs	A 0.4 volt decrease in phase C voltage over a 3 second interval.
116 secs.	A 0.4 volt increase in phase A and C voltage over intervals of 1.5 and 3 seconds, respectively. A 0.4 volt decrease in phase B voltage over a 1.5 second interval. A 1.2 cycle increase in inverter frequency over an interval of 3 seconds. All of these measurements had recovered after an interval of 9 seconds.

The inverter phase B voltage, as measured at the guidance system, exhibited the same varying characteristics that have been observed during "D" and "E" Series flight tests.

OPTICAL BEACON SYSTEM

Evaluation of the Optical Beacon System was precluded due to absence of an activation signal. The Inertial Guidance System did not transmit the sustainer cutoff discrete due to premature sustainer engine shutdown and the manual fuel cutoff signal was locked out of the programmer at the time of transmission (351.0 seconds) and could not activate the Optical Beacon System. Telemetered data verified that telemetry Channel 1-C did not switch to monitor system operation.

RANGE SAFETY COMMAND SYSTEM

Performance of the Range Safety Command System was satisfactory. Telemetered r-f input/agc data indicated that received signal strength was adequate to maintain proper airborne system operation during the flight.

The manual fuel cutoff signal was transmitted by AMR as planned at 350 seconds wnd was decoded by the airborne system at 351 seconds. There were no inadvertent command system outputs. The ASCO discrete was not generated during this flight due to premature sustainer engine shutdown.

AZUSA SYSTEM

Performance of the Azusa System was satisfactory. Azusa Mark II tracked actively and Azusa Mark I tracked passively during the flight. Real time impact prediction plots were obtained during powered flight and trajectory information was obtained until approximately 273 seconds at Azusa Mark II.

Solid r-f lock was acquired by the AMR ground station at 7 seconds. The tracking system was in fine mode in range, prior to and after liftoff, and in all cosines by 18 seconds. After 18 seconds an ambiquity occurred in ℓ cosine and was again resolved to fine by 30 seconds.

During the countdown, AMR reported satisfactory transponder operation. Received signal strength at Azusa Mark II was -120 DBW at -22 minutes (2242 EST). Recovery, modulation, and coherency were satisfactory. The airborne system utilized an elliptical horn antenna mounted in Quad IV for this flight.

During the automatic sustainer cutoff (ASCO) confidence test the 709 computer did not generate the (ASCO) discrete because preset conditions were not satisfied for this flight. This signal would have been generated open-loop by the computer.

FLIGHT CONTROL SYSTEM

Performance of the Flight Control System was satisfactory. Missile stability was maintained until after sustainer engine shutdown and there were no missile bending mode buildups observed. Thrust chamber displacements at engine start were well within the allowable tolerance of $\pm$ 0.6 degrees. The roll maneuver was properly generated by the Inertial Guidance System and was satisfactorily accomplished. The electronically generated booster pitch program was also satisfactorily accomplished. The Inertial Guidance System pitch resolver null setting on this flight was 73 degrees. This resulted in an additional 10.23 degrees pitchover after guidance enable. This additional pitch maneuver was accomplished satisfactorily. The guidance booster cutoff discrete was properly acted upon and response to guidance steering commands was satisfactory prior to sustainer engine shutdown. The staging sequence and staging transients appeared normal. Data indicated that the programmer switching functions were accomplished satisfactorily.

Since the sustainer and vernier cutoff discretes were not generated by the Inertial Guidance System due to the fuel depletion shutdown, the programmer reached the vernier cutoff condition (400 seconds digital clock time) at staging discrete plus 200 seconds nominal and initiated Subroutine 3. This subroutine was evidenced by pre-arm backup at 338 seconds, re-entry vehicle separation at 339 seconds, and retro-rockets firing at 340 seconds. These functions occurred approximately one second early due to the missile inverter operating levels after staging.

The programmer did not initiate Subroutine 2 (which at the sustainer cutoff discrete signal normally activates the vernier engines in pitch and yaw, the strobe light, the sustainer engine cutoff signal, and telemetry channel 1-C switchover) due to the lack of a sustainer cutoff discrete input signal to the programmer prior to reaching the vernier cutoff condition. Upon reaching the vernier cutoff condition, the programmer locks out any discrete input signals. Therefore, although the manual fuel cutoff signal supplied a sustainer cutoff signal to the programmer input at 351 seconds, Subroutine 2 was not activated.

It is possible that vernier cutoff would not have occurred on this flight from the Inertial Guidance System discrete signal since it was planned for 323.9 seconds which was slightly more than 200 seconds after the staging discrete. On future long-range flights the time of Subroutine 1 will be increased from 200 seconds to 265 seconds.

A divergent buildup of propellant slosh in the pitch plane reached maximum rate at booster cutoff of 2.4 degrees/second, peak-to-peak, at a frequency of 1.5 cps. Booster engine motion in pitch at booster cutoff was 1.2 degrees, peak-to-peak.

A pitch-up acceleration of 14.8 degrees/sec^2 began approximately 0.10 seconds after the start of booster jettison. Similar pitch-up accelerations were observed during booster jettison on Missiles 8E and 9E. This condition is tentatively attributed to deflection of the sustainer exhaust by the booster package while the booster package is still in contact with the missile.

The Flight Control System on Missile 13E was modified in the same manner as Missile 9E except for instrumentation changes. The instrumentation installed on this missile consisted of five vernier temperatures and are discussed in the Airframe section of this report.

INERTIAL GUIDANCE SYSTEM

Operation of the Inertial Guidance System was satisfactory. Booster cutoff discrete and pitch and yaw steering commands were properly generated; but SCO, VCO, and Prearm conditions were never attained due to premature engine shutdown resulting from fuel depletion.

Target offsets of -0.0009 degrees latitude and -0.0149 degrees longitude were inserted in the Inertial Guidance System to compensate for revised re-entry drag coefficient and vernier thrust decay.

All Inertial Mode Start occurred at 2317:11.2185 EST.

Reliability

There were no guidance system malfunctions throughout countdown and flight.

Accuracy

Preliminary evaluation indicated satisfactory guidance system accuracy. However, accuracy evaluation data were limited because the flight was prematurely terminated. Comparison of the Inertial Guidance System telemetered velocities with Mod III velocity data at the end of powered flight indicated the small velocity errors listed below:

X Velocity	+1.09	fps
Y Velocity	-6.96	fps
Z Velocity	-2.87	fps

These values do not contain all available corrections and are approximate, but indicate that no excessive errors existed.

Trajectory

From liftoff to booster cutoff, the flight agreed very closely with the nominal trajectory, not exceeding 1/2 sigma deviations. Between staging and sustainer shutdown the net acceleration was an estimated 4 percent high (based on velocities at shutdown), but the flight path was otherwise nominal. Fuel depletion caused sustainer shutdown at 252 seconds and terminated the flight with impact occurring approximately 2,000 miles from the launch point.

The magnitudes of the velocities and positions indicated by the computer at staging are given in the table below:

Conditions at Approximate Time of Guidance Enable

Function	Units	Nominal	Actual	Difference[1]	Approx. 3 Sigma Limits
t	sec.	128.0	128.968	±0.97	6 sec.
$\dot{x}$	ft/sec.	9234.25	9235.25	±1.0	70 fps
$\dot{y}$	ft/sec.	2026.25	2018.5	-7.75	600 fps
$\dot{z}$	ft/sec.	4288.50	4398.5	±110.0	950 fps
x	ft.	441,280	449,664	±8,384	20,000 ft.
y	ft.	140,992	145,664	±4,672	25,000 ft.
z	ft.	223,552	230,528	±6,976	35,000 ft.

[1] Actual minus nominal.

Platform and Control

The Missile Guidance Set (MGS) provided roll control from the azimuth resolver between 2 and 19 seconds. The signal was satisfactorily supplied, reducing the azimuth resolver signal to zero degrees at 19 seconds. After guidance steering enable, the azimuth resolver indicated a right turn and went out of the instrumented range (-7.5 degrees). After one turn back into the instrumented range, the signal remained at band edge. This was due to the azimuth resolver zero being offset 8.8 degrees for the "dog-leg" portion of the flight.

At guidance steering enable, the pitch resolver signal was outside of the instrumented band which indicates more than 5 degrees from nominal. This was reduced to zero degrees by enable plus 22 seconds.

During the first portion of the flight, the roll resolver indicated zero degrees. After guidance steering enable, the roll resolver indicated the roll component of the yaw maneuver and arrived at a final value of 2.2 degrees. This is a proper indication for "dog-leg" flights.

All servo errors were less than 0.5 minutes (arc) until the platform tumbled.

Gyro drifts measured prior to launch were.

Drift	Value deg/hr	Measurement Made
Azimuth	-0.32	Precount
Roll Fixed	-0.11	X-1 Day
Pitch	-0.26	X-1 Day

These values are within the tolerances and are consistent with past history. Redundant gyro torquing currents were of low amplitude throughout the flight and similar to Missile 9E. Maximum excursion occurred during the slosh period.

Gyro temperatures with respect to neutral buoyancy during the flight were.

Pitch/Redundant	601	$+0.5^{\circ}$ C
Roll/Azimuth	602	-0.2 to -0.4° C

Performance of the accelerometers was satisfactory. Scaling measurements made during the tests prior to and on the launch day were consistent. Scale factors which were measured during the precount and countdown were as follows.

Scale Factor	X	Y	Z
cps/ft/sec^2	2.00092	2.00023	1.99953

The mag amp oscillated normally through the $60 \pm 0.1^{\circ}$C instrumented range.

Platform pressure was steady throughout the flight. The reading was 4 psia which indicates the calibration is questionable.

Computer

Computer operation was satisfactory. A data checker evaluation run, with one correction for telemetry dropout, indicated agreement between the outputs of the flight computer and a reference computer. BCO was issued correctly but the conditions for SCO, VCO, and Prearm were never reached.

Yaw steering was saturated right from 100 seconds through staging plus 1.5 seconds (125 seconds). At this time (prior to guidance enable) the signal changed abruptly to a low level left command which at guidance enable (129.6 seconds) resulted in a left turn of roughly 0.5 degrees over a 2 second period. At guidance enable plus 2.5 seconds, a near-saturated right command was issued, turning the missile right at an initial rate of approximately 1.4°/sec. Duration of this command was roughly 9 seconds. The change in azimuth is not readable on the azimuth resolver channel due to limiting of its output, but the roll resolver indicated a right turn of 7.8 degrees in the platform azimuth plane. After one appreciable overshoot, the yaw steering became essentially zero and remained so through sustainer shutdown.

All data checker tests for telemetry quality during the countdown were satisfactory.

Computer voltages were normal. Typical values are as follows:

Computer Voltages

Time	-10V	±16.5V	-50V	±38V	±4V
-5	-10	16.75	-48.7	±37	±3.8
±10 sec.	-10	16.5	-48.7	±37	±3.7
±250 sec.	-9.8	16.4	-48.7	±37	±3.7

Computer temperature was 28°C at reset and rose to 34°C at 294 seconds.

Alignment-Countdown Set (A-CS)

A-CS performance was satisfactory. Accelerometer zeros were within the specified tolerances as measured by the A-CS immediately after the loops were opened, indicating proper operation of the zeroing loops.

Function	Nominal	Compensated Nominal	Measured	Error (cps)
X-Offset	0.667	0.57997	0.57916	-0.00081
X	1.000	--------	1.00158	∮0.00158
Y	1.000	--------	1.00083	∮0.00083
Z	65.25407	65.24048	65.24236	∮0.00188

Instrumentation

All channels of the Analog Signal Converter (ASC) functioned properly. ASC temperature was constant at 20.1°C throughout the flight. The questionable reading of the binnacle pressure channel was most probably due to incorrect transducer calibration.

Digital Signal Converter (DSC) performance was satisfactory. Overall telemetry quality was the best seen on the E series. The only significant dropout occurred at separation with a duration of 0.4 seconds.

MOD II RANGE SAFETY AND INSTRUMENTATION SYSTEM

Performance of the Mod III Range Safety and Instrumentation System was satisfactory after 104 seconds. The tracker locked on a side lobe during the early flight phase and characteristics were similar to track performance on Missile 9E. This was corrected at 104 seconds and monopulse tracking was established on the correct lobe after a short period of conical mode operation. The rate data were satisfactory during the entire flight. The performance of the computer and the rate subsystem was satisfactory.

The automatic sustainer cutoff signal (ASCO) was not generated because of the early termination of the flight.

Telemetered data indicated satisfactory operation of the airborne system. Measurement G 589 P, Waveguide Pressure 2, indicated intermittent dropouts between 111.0 and 124.8 seconds. At 124.8 seconds the measurement appeared to be open electrically and data were invalid after this time. During this interval, measurement G 587 O, Pod waveguide, indicated an increase from approximately 21 G's to greater than the band limit of 30 G's. This was a continuation of a general increase observed during booster phase. The boom antenna and rate beacon radial vibration measurement indicated normal vibration levels during the flight.

Performance of the individual subsystems was as follows:

Track Subsystem

Performance of the track subsystem was satisfactory except from 40 to 104 seconds. During this period the data show that the antenna tracked off the missile to the right in azimuth until the low signal level being received indicated a shift of mode to conical hold. Reacquisition in monopulse mode was accomplished within 4 seconds and the track system operated satisfactorily until the end of flight. At the time of reacquisition, the position error was as follows:

Azimuth	59 mils right
Elevation	Negligible
Range	Negligible

The received signal strength during the 40 to 100 seconds period slowly declined from -30 dbm at the start to -67 dbm at the swtich to conical hold. The cause of this behavior of the tracker is under investigation and at present no definite reason has been found.

It is noted that the track performance on the launch of Atlas Missile 9E was similar to that on Missile 13E. The possibility of the existence of an unfavorable missile antenna look angle at this stage of the flight is being studied.

The remainder of the tracking period from 104 seconds until the limit of range at 454 seconds was satisfactory. Monopulse lock was maintained until 274 seconds, about 22 seconds after sustainer shutdown. At this time, a slow decline of the agc indicates a changing antenna look angle. Tracking from this time on was on an intermittent basis.

The peak-to-peak tracking errors during the sustainer phase were 0.08 mils in elevation and 0.12 mils in azimuth. The average received signal strength was -50 dbm during the sustainer phase of flight.

Rate Subsystem

Rate subsystem performance was satisfactory. All rate functions were locked at 43.6 seconds and all good rate flags were recorded 2.5 seconds later. An expected brief rate sweep occurred during booster separation at 127.5 seconds. From this time, continuous rate lock was maintained until 273.5 seconds.

Although the rate antennas were pulled off target by track during early booster phase, the rate subsystem remained locked on a low, varying signal which averaged -96 dbm. At 101 seconds, when the tracker reacquired the missile, the rate antennas were re-positioned on target. At this time all rate signals increased an average 26 dbm in level and averaged -80 dbm for the remainder of booster phase. During the sustainer phase an average signal level of -88 dbm was received.

Beginning approximately 15 seconds after premature sustainer shutdown, the received signal level rapidly rolled off to noise and rate unlocked at 273.5 seconds. From this point, due to recurring missile attitude change, an intermittent loss of signal occurred and resulted in several periods of rate unlock. Final loss of signal and rate lock occurred at 452 seconds.

A-1 Computer

The computer operated satisfactorily during the countdown and ensuing flight. A simulated rerun of the flight was made utilizing the tape edit program with no deviation from the real time results.

A calculation based on data gathered between 317 seconds and 334 seconds placed the impact point at 51.74° West Longitude and 11.01° North Latitude. Due to the early termination of the flight, the ASCO discrete was not generated. The ASCO inhibit switch remained in the "OFF" position throughout the flight.

After approximately 104 seconds, a good IIP plot was presented to the Range Safety Officer. This plot was displaced to the left and north of the nominal trajectory and out of the 3 sigma limits. However, Arma instrumentation data from the same radar data indicated a near nominal flight. An investigation revealed that the erroneous plot was an anomaly of the transformation equations. By necessity, the center of the transform equation (and their constants) used for this flight is in the area of the target so as to make the IIP valid in the critical area of the flight, (corridor through the destruct line near South Africa). This condition existed on the flight of Missile 9E, although not as pronounced as on this flight

RE-ENTRY VEHICLE

A Mark 3 Mod IB Re-entry Vehicle, Serial No. 230, was flown on Missile 13E. This vehicle was different from the standard Mod IB in that it did not have a beacon or SOFAR bombs, and a dummy "C" section was utilized instead of a Sandia section.

The instrumentation subsystem functioned normally at liftoff and during flight. All uprange events occurred normally. Due to missile malfunction, the vehicle only traveled approximately 1850 nm, therefore, no re-entry data were obtained.

Significant events and launch information were as follows

Pre-arm	337.9 sec.
Separation	339 sec.
Separation Rate	-5 Inches/Sec.
Spin Rate	-70 Degrees/Sec.

CONVAIR PROPELLANT UTILIZATION SYSTEM

Performance of the Propellant Utilization (PU) System was unsatisfactory. The PU valve failed to respond to the Error Demodulator Output (EDO) throughout powered flight. This resulted in fuel depletion with subsequent premature sustainer engine shutdown at 252 seconds.

The PU valve went normally to the full open position at ignition start. After this time, however, throughout booster and sustainer phase, the valve apparently remained at this position, or at least at an angle greater than 65 degrees which is the telemetry information band limit. The Head Suppression (HS) valve, however, went properly into control and was positioned between 32 and 29 degrees throughout booster and sustainer operation. At sustainer shutdown, the PU valve went to the full closed position and the HS valve went to the full open position as would be expected under the existing conditions.

Preliminary investigation indicates that the failure of the PU valve to respond correctly to the EDO signal can be attributed to not supplying closing control pressure to the PU valve actuator. This could have been the result of a failure in several electrical or mechanical components whose operation cannot be determined with available instrumentation. Areas of suspicion include electrical components in the PU System Controller Assembly, loss of electrical continuity between the PU System Controller Assembly and the coils on the PU Servo Control Flapper, a failure to actuate the PU Servo Valve in the hydraulic control package either by not moving the spool mechanically or not actuating the flapper valve electrically, or a malfunction of the PU Auto-Control Valve in the hydraulic control package. The above mentioned components are illustrated in Figures I and II of this section. Further investigation is being conducted and tests are being performed to determine the exact cause of the failure.

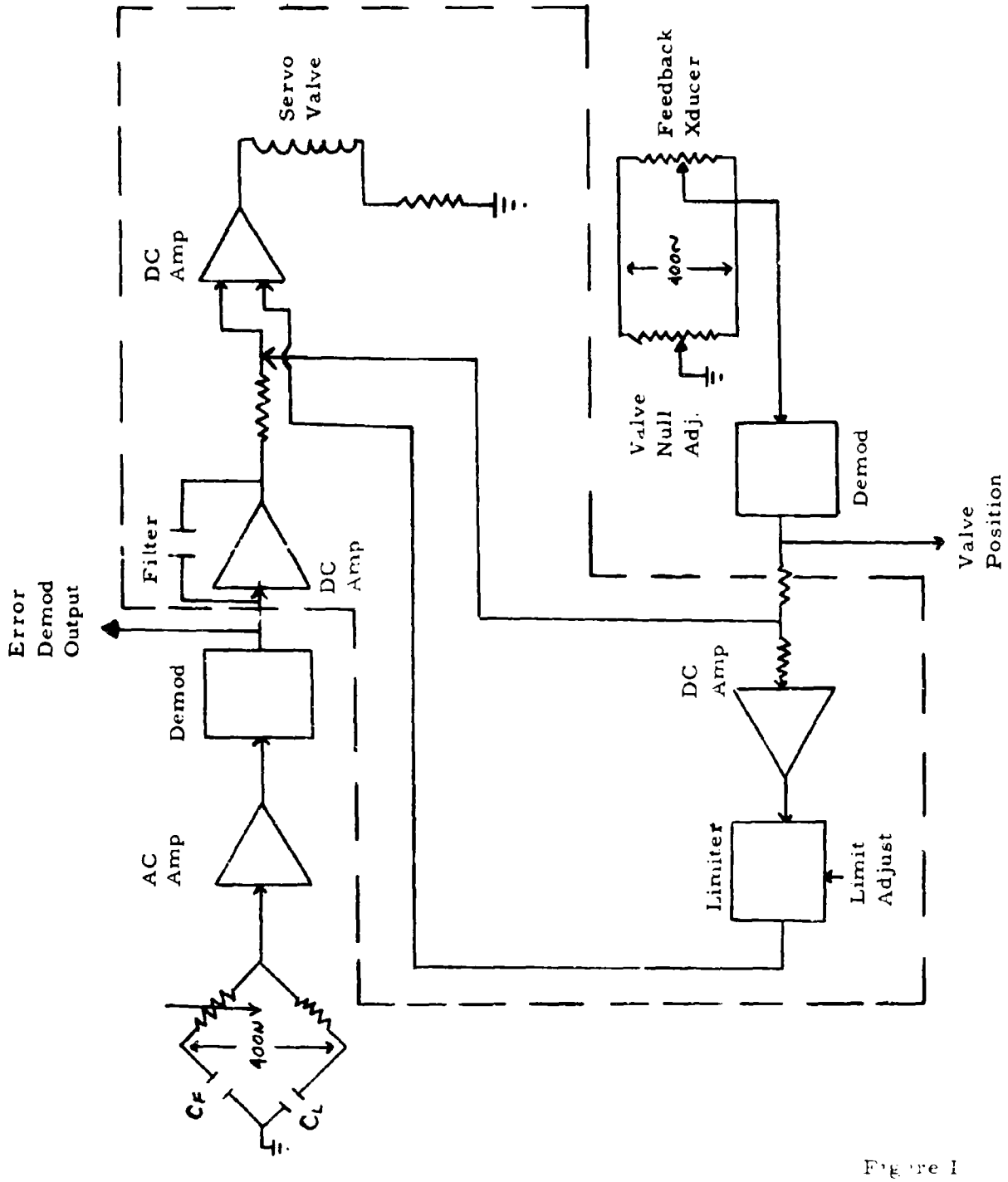
The EDO after servo-control acquisition was approximately at null at 10 seconds and then gradually increased to the upper information band limit of $+5$ volts by 88 seconds as the result of the higher than normal fuel consumption.

The fuel head sensing port data indicated the port uncovered at approximately 242.3 seconds, or 9.4 seconds prior to sustainer shutdown. The LO2 head sensing port data indicated a pressure of approximately 4.6 psi throughout the flight until sustainer shutdown.

The following constants are applicable to Missile 13E.

Matched Set No.	620
Upper Electrical Limit	47.2 Degrees
Nominal Valve Angle	29.5 Degrees
Mechanical Stop	22.0 Degrees
EDO Sensitivity	+0.838 VDC/Percent

PROPELLANT UTILIZATION SYSTEM
(Electrical Components)



Area within dashed lines includes components whose operation cannot be determined from available instrumentation.

Figure I

~~SECRET~~

CONVAIR-ASTRONAUTICS

PROPELLANT UTILIZATION SYSTEM

(Mechanical Component.)

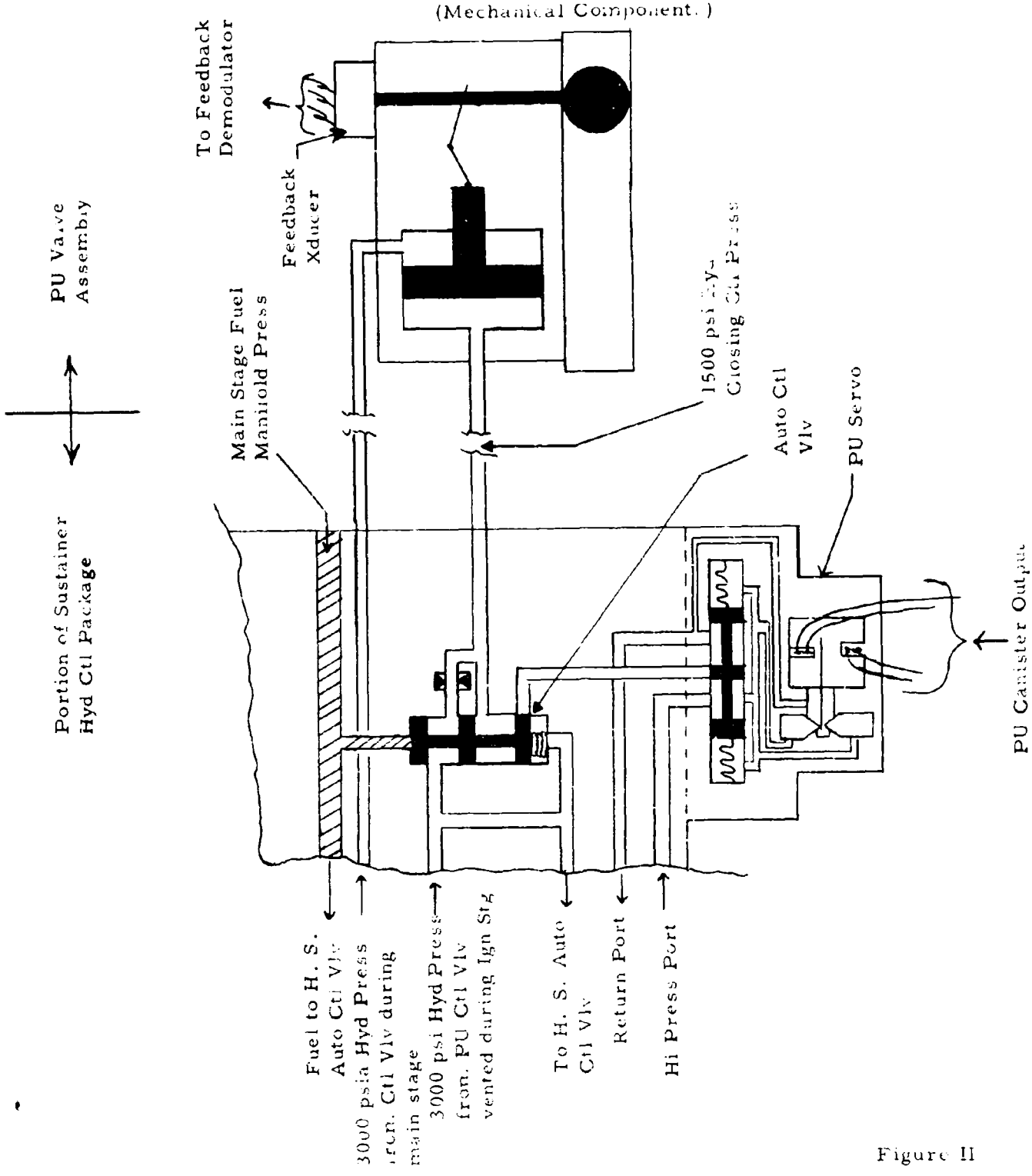


Figure II

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PROPELLANT TANKING

Propellants were tanked utilizing the Propellant Loading Control Probes (PLCU).

Fuel was initially tanked on X-1 Day on 9 March, and remained aboard the missile until launch on 13 March. Flight level was obtained by tanking slightly above the 100.2 percent PLCU probe. As a result of fuel density changes during the period that fuel remained aboard, several adjustments of unknown quantity were made to the fuel level. This made it impossible to determine actual fuel density at ignition. The 100 percent PLCU probe deactivated at 13.79 psig indicating that the fuel level was slightly above the probe prior to LO2 tanking.

LO2 tanking was accomplished during the countdown. The LO2 level was above the 95 percent PLCU probe level when the drive belt on Pump LC broke. The count was held at -5 minutes while LO2 flow was switched to the 6 inch fill line and the topping line. The LO2 storage tank was then pressurized to 40 psig producing sufficient head pressure to continue tanking the missile. Upon activation of the topping high probe, the 6 inch line was secured and the level was maintained by flow through the topping line.

Boiloff loss was great enough to deactivate the topping high probe at approximately -1 minute 45 seconds. Tanking was concluded with a successful slug of 43 seconds duration. LO2 level at ignition was at the 100 percent slug cutoff probe.

The fix in the topping high probe circuitry incorporated on Missile 9E to prevent the topping high probe relay from dropping out as a result of flight pressurization, was also incorporated on Missile 13E. Operation of the relay was satisfactory.

Weather Data

	Fuel Tanking	Ignition
Ambient Temperature	60.2°F	63.4°F
Barometric Pressure	29.930 Inches of Hg.	29.940 Inches of Hg.
Relative Humidity	41 Percent	63.4 Percent
Wind-Velocity and Direction	20 Knots-WNW, Gusts-30 Knots	5 Knots-SW
Cloud Coverage	8/10	Light Rain 10/10

AIRFRAME INTERNAL INSTRUMENTATION

Excellent telemetry data were obtained throughout powered flight. There was one burst of noise at staging which lasted less than one second. Telemetry signals were received at the cape for approximately 15 minutes.

The three breakwire measurements on the sustainer engine control hydraulic package and manifold showed level changes between liftoff and 18 seconds. These levels dropped to approximately 85 percent IBW. The last change was not indicative of a broken wire but instead appeared to have been caused by a temporary shift in the measurement excitation voltage which was provided by an independent 5 volt power supply in the accessory package.

There were five measurements which did not operate properly.

Measurement No.	Description	Comments
H 398 P	NAA Hyd Accum Gas	Did Not Activate
G 589 P	Waveguide Press 2	Open at 112 Seconds
S 385 V	Accel 400 Cycle Cont	Did Not Activate
S 359 X	Booster Staging B/U	Open
P 713 T	B1 Gas Generator Combustor	Data Qualitative-Segment Spiked.

Missile 13E contained three Bendix Mod 7 FM telemetry packages, operational at the following frequencies and with the following subcarriers and commutation capabilities.

RF No.	Frequency	Continuous Channels	Commutated Channels
1	227.7	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	11, 12, 13, A, C, E
2	229.9	2, 3, 4, 5, 6, 7, 8, 9, 10, 12, A, C	11, E
3	232.4	4, 5, 7, 9, 13, A, C, E	11, 12

Basic telemetry channel assignment is given in Convair Report AZC-27-059-13. Included in that report are channel assignment, commutation information, frequency response, and make and model of transducer.

LANDLINE INSTRUMENTATION

The Landline Instrumentation System provided satisfactory information prior to missile liftoff.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The flight was unsuccessful.

2. The flight failure was caused by a malfunction of the propellant utilization system.

3. Mod III instrumentation system tracked in a false-lock mode from 40 to 104 seconds.

Recommendations

1. Perform analysis and tests of the electrical and mechanical components of the propellant utilization system to isolate the problem area.

2. Add appropriate instrumentation to the propellant utilization system for the purpose of isolating the problem area in the event of a recurrence of the malfunction.

3. To extend track capabilities of the Mod III instrumentation system during the early phase of flight; an analysis of antenna look angles should be made and the operational procedures should be reviewed.

COUNTDOWN TIME VERSUS EVENTS

This test was scheduled for a 150 minute countdown and started at 1800 EST as planned. There were two holds totaling 166 minutes which resulted in a 316 minute countdown. The holds were required as follows.

1. At -45 minutes (1945 EST), for 154 minutes, due to adverse weather conditions which prevented attaining mandatory camera coverage. When satisfactory camera coverage was attained the count was resumed at 2219 EST.

2. At -5 minutes (2259 EST), for 12 minutes, due to loss of LO2 pumpLC. After investigation, LO2 transfer was attempted by increasing the pressure in the LO2 storage tank. When it was determined that LO2 transfer was being accomplished. The count was resumed at 2311 EST and no further difficulties were encountered.

The following notations were made by an observer in the blockhouse.

EST	Countdown Time	Countdown Procedure	Event
1800	T-150	T-150	Countdown Started.
1800	T-150	T-150	Gap Test Preparation Started.
1806	T-144	T-144	Readiness Callout by Flight Control.
1807	T-143	T-144	Gap Test Started.
1813	T-137	T-138	Gap Test Completed Satisfactorily.
1814	T-136	T-138	Start Electrical Installation of Retro-Rocket.
1816	T-134	T-135	Range Safety Command Tests Started.
1825	T-125	T-125	Start Electrical Connection of Red Destruct Box.
1825	T-125	T-125	Range Safety Command Tests Completed.
1828	T-122	T-120	Red Destruct Box Installation Finished.
1834	T-116	T-90	AIGS Ready For Removal of Landlines.

EST	Countdown Time	Countdown Procedure	Event
1840	T-110	T-95	Service Tower Removal and Securing Started.
1850	T-100	T-100	Flight Control System Test Started.
1900	T-90	T-100	Flight Control System Test Completed.
1900	T-90	T-100	Nose Cone Telemetry and Beacons "ON".
1905	T-85	T-85	Helium Pressure Storage Preparation Started.
1913	T-77	T-75	Helium Storage Preparation Finished.
1914	T-76	T-70	Helium Storage Started.
1925	T-65	T-65	Start Landline Electrical Calibrations.
1930	T-60	T-60	Reduce Helium Pressure to 1300 psia.
1935	T-55	T-55	Gap Test Preparation Started.
1938	T-52	T-52	Gap Test Started.
1939	T-51	T-50	Landline Electrical Calibration Completed.
1944	T-45	T-52	Gap Test Completed (Go Test).
1945	T-45H	T-45H	Holding For Rain to Stop and RCA Optics to get their Cameras Back in Operation.
1956	T-45H	T-45H	Two Cameras on Top of Ramp are Secured.
2-40	T-45H	T-45H	Holding Indefinitely for Weather.
2154	T-45H	T-45H	All Personnel on Station for Gap Test.
2157	T-45H	T-45H	Telemetry Coming Up.
2200	T-45H	T-45H	Gap Test Delayed Approximately 5 Minutes to Replace Pre-Amp in Pitch Gyro Output.
2206	T-45H	T-45H	Readiness Callout by Flight Control.

EST	Countdown Time	Countdown Procedure	Event
2207	T-45H	T-45H	Gap Test Started.
2213	T-45H	T-45H	Gap Test Completed Satisfactorily.
2216	T-45H	T-45H	All Systems Ready to Pick up Count.
2219	T-45	T-45	-45 Minutes and Counting.
2219	T-45	T-45	LO2 Tanking Preparation Started.
2220	T-44	T-40	Missile Lockon Test Satisfactorily Completed.
2231	T-33	T-35	LO2 Tanking Started.
2234	T-30	T-30	Flight Control System Final Check Started.
2239	T-25	T-25	Final Computer Checks Started.
2242	T-22	T-22	Turn Azusa "ON".
2243	T-21	T-22	Final RSC Checks Started.
2246	T-18	T-20	Telemetry Final Warmup.
2249	T-15	T-35	Retract Holddown Hooks.
2254	T-10	T-10	Telemetry/RSC AGC Check Started.
2255	T-9	T-10	Final RSC Checks Completed.
2256	T-8	T-6	Flight Control Final System Check Completed.
2259	T-5H	T-5H	-5 Minutes and Holding.
2301	T-5H	T-5H	Will Attempt LO2 Pressure Transfer Through Six Inch Line Due to Failure of Pump LC.
2308	T-5H	T-5H	Status Check All Systems "GO" Except LO2 Control. LO2 Control Progressing Satisfactorily.
2309	T-5H	T-5H	EDO Trend Still Toward Zero.

EST	Countdown Time	Countdown Procedure	Event
2311	T-5	T-5	-5 Minutes and Counting.
	T-4:30	T-4:30	Squib Disarm Switch to "OFF".
2312	T-3!50	T-3:50	Status Checks - All Systems "GO".
	T-3:30H	T-3:30H	Holding Momentarily.
	T-3:30	T-3:30	-3 Minutes and 30 Seconds and Counting.
	T-3:30	T-3:30	Telemetry to "INTERNAL".
2314	T-3:00	T-3:00	Timers ready switch to "READY".
	T-2:45	T-2:45	Shutdown Power Switch to "ARM".
	T-2:15	T-2:15	Nose Cone Telemetry to "INTERNAL".
2315	T-2:05	T-2:05	Commands to "INTERNAL".
	T-1:55	T-1:55	Autopilot to "ARM".
	T-1:50	T-1:50	Turning Water Systems "ON".
	T-1:45	T-1:45	Commands to "ARM".
	T-1:45	T-1:45	Evacuation Lights "ON".
	T-1:35	T-1:35	-1 Minute and 35 Seconds and Counting.
	T-1:35	T-1:35	Proceeding to Flight Pressurization.
	T-1:10	T-1:10	Missile to "INTERNAL POWER".
	T-1:05	T-1:05	Missile Helium to "INTERNAL".
2316	T-0:60	T-0:60	-60 Seconds and Holding.
	T-0:60	T-0:60	100 Percent Slug Light "ON".
	T-0:60	T-0:60	Slug Complete Light "ON".

EST	Countdown Time	Countdown Procedure	Event
2316	T-0:60	T-0:60	-60 Seconds and Counting.
	T-0:50	T-0:50	Water Full Flow.
	T-0:35	T-0:35	Status Check - Pressurization and Missile Power "GO".
	T-0:35	T-0:35	All Launch Commit Lights are Correct.
	T-0.05	T-0:05	Holding Momentarily at -5 Seconds.
	T-0.05	T-0:05	All Recorders to "FAST".
	T-0 01	T-0:01	Ignition Start.
2317 17			Range Zero Time.

MISSILE CONFIGURATION

Airframe

SM-65E Missile approximately 71 feet long from re-entry vehicle interface to aft surface of thrust chambers. With re-entry vehicle attached, complete missile is approximately 81 feet long. Missile structure comprised of booster structure and main propellant tank structure.

Booster structure changed from "D" Series configuration to accomodate MA-3 Propulsion System and free launch concept. Aft nacelles were shortened and booster structure contours generally changed. Four support longerons added to outside surface of booster structure, each equipped with slot at aft end to accomodate launcher holddown hooks utilized during flight readiness firings. Fuel fill line placed inside booster structure and each booster engine has its own LO2 feed line. Because of free launch concept, clamshell doors were deleted. Booster structure separation accomplished by four modified pneumatic mechanical separation fittings.

Azusa System

Type B-1A coherent carrier transponder in conjunction with Mark II ground tracking facilities. Elliptical horn antenna mounted in Quad IV. Tilted beam antenna in Quad III not connected.

Electrical System

Bendix rotary inverter, remotely activated Yardney missile main battery and three telemetry batteries (Two Eagle Pitcher and one Yardney). Manually activated Range Safety Command Yardney battery.

Flight Control System

Square canister configuration with forward rate gyro package containing pitch and yaw rate gyros. System configuration modified by addition of a "pink box" in B2 pod. This box incorporated vernier pitch current limiting resistors and resistors to reduce booster open loop gains. Other modifications included additional aluminum wrapping on vernier area wiring to provide better insulation, stainless steel cover plates on vernier clamshell fairings to seal off openings, and 28 degree stops on vernier pitch actuator travel. Additional instrumentation added to measure five vernier temperatures.

Guidance System

Third flight test for Arma Lot IV inertial guidance. Lot IV same as Lot IIIm versions flown with D/AIG and first two "E" Series missiles, with two exceptions.

1. An extra pendulum incorporated to allow system to go to -1g for "X" accelerometer without making complicated ground resolver changes.
2. Improved type gyros with angular momentum of 10^7 CGS units.

Hydraulic Systems

Comprised of three independent systems which provide hydraulic pressure for booster operation, sustainer/vernier operation, and a 25 cubic inch accumulator for vernier solo operation.

Riseoff disconnect panels shielded and protected from radiant heat and recirculation by installation of a plate covering entire disconnect panels with holes for the disconnects and with telescoping tubes protecting each individual disconnect. TVA A32822-1 installed standard check valve in booster hydraulic high pressure line above riseoff disconnect and aluminum sustainer and booster high pressure tubing between the riseoff and staging disconnects. Sustainer high pressure line to stage disconnect valve located on staging rail rerouted to prevent possible interference between line and rail.

TVA A 32822-5 installed aluminum tubing in the apex area between the staging disconnect and the sustainer engine. Also installed a standard check valve in sustainer hydraulic system above staging disconnect as close to the cross fitting as possible, and substituted stainless steel lines for original tubing throughout high and low pressure sustainer engine hydraulic system. High pressure lines to sustainer accumulator relocated to prevent possible interference with structure.

Rocketdyne sustainer hydraulic control package changed to incorporate instrumentation and design improvements.

Impact Predictor

Azusa B-1A and Mod III E instrumentation beacon system.

Re-entry Vehicle

Mark 3, Mod I B, two telemetry links active at 237.8 and 244.3 mc. No SOFAR bombs or "C" band beacon were carried.

Pneumatic System

Basic Convair system of 5 shrouded main propellant tank pressurization titanium helium bottles, and one ambient bottle for vernier solo propellant feed, PU bubbler operation, and booster jettison. Stratos LO2 tank pressure regulator relocated to jettison with booster section.

Propulsion System

Rocketdyne standard production MA-3 liquid engine propulsion system. Single accelerometer and a 15 foot cable installed on each booster engine to measure engine vibrations resulting from combustion. No cutoff capability.

Propellant Utilization System

Convair PU (Manometer) System with 400 cycle feedback, and unitized chassis.

Range Safety Command System

Standard system with two ARW -62 receivers, a power and signal control unit, and destruct package.

Propellant Tanking

Convair "E" Series propellant tanking system incorporating four ultrasonic fuel sensors, four LO2/GO2 detectors, a propellant loading control unit (PLCU) in the blockhouse, and a 200-400 gallon sub-cooled LO2 slug.

Telemetry System

Three airframe telemetry links operational at 227.7, 229.9, and 232.4 mc.

Strobe Optical Beacon System

Mounted on forward fairing of B2 equipment pod. Activation programmed to occur at SECO / 0.5 seconds.

HISTORY OF SM-65E MISSILE NO.13

Atlas Missile 13E arrived at AMR by air transport on 13 January 1961. Transfer from the IOC trailer to the R and D trailer was accomplished in Hangar H the same day. The missile remained in temporary storage in Hangar H until 20 January 1961, when further transfer to the north bay of Hangar J was effected. Pre-erection modifications and some system checkout was initiated in Hangar J; however, since All-Inertial Guidance System tasks can only be accomplished in Hangar K, it was necessary to delay AIG system checkout pending transfer of Missile 9E from Hangar K to Complex 13 and subsequent hangar space availability. On 30 January 1961, Missile 13E was positioned in the south bay of Hangar K and necessary hangar tasks were initiated.

On 27 February 1961, after remaining in the hangar area for approximately six weeks, the missile was weighed, transported to Complex 13, and erected. One attempted launch was performed on Missile 13E; the attempt being cancelled at -30 minutes in the countdown due to loss of deviation on RF No. 1 which could not be corrected before launch cutoff time. The complete attempted launch countdown is presented in this section of the report.

Missile 13E remained at AMR for a period of approximately nine weeks before being launched. The greater portion of this time was utilized in performing system checks and accomplishing modifications. and in readying the missile/launch complex for the flight test. Pre-launch operations were accomplished in accordance with planning documented in Report AA 60-0142, Flight Test Directive, Atlas Missile 13E. Tests and unplanned operations arising from trouble shooting and/or test discrepancies were performed on an "as required" basis.

Significant events concerning Missile 13E from arrival at AMR to launch are delineated chronologically below.

Date	Event
13 January 1961	Arrived at AMR by air transport, stored in Hangar H.
20 January 1961	Positioned temporarily in north bay of Hangar J.
30 January 1961	Transferred to south bay of Hangar K for hangar checkout.
27 February 1961	Weighed. transported to Complex 13 and erected.
2 March 1961	Successful Propellant Tanking.

Date	Event
6 March 1961	Successful Flight Acceptance Composite Test. Two countdowns were performed, the first starting at -150 minutes and the second at -10 minutes. During the first run, fuses inserted to monitor inactive circuits of stray voltages were blown. It was discovered that this was a result of procedural error and the second run verified satisfactory performance. Changed V2 engine because of hydraulic leak at gimbal shaft seals.
9 March 1961	X-1 Day Operations.
10 March 1961	Attempted launch. Terminated at -30 minutes due to loss of deviation on RF No. 1 which could not be corrected before launch cutoff time.
12 March 1961	X-1 Day Operations.
13 March 1961	Flight.

Attempted Launch

One attempted launch was performed on Missile 13E. An observers notes concerning this attempt follows.

Countdown Times Versus Events P3-501-00-13 (10 March 1961)

This test was scheduled for a 150 minute countdown and started as planned at 1745 EST on 10 March 1961. There were two holds and three recycles required which accounted for an additional 205 minutes which resulted in a total countdown time of 325 minutes. The holds were as follows:

1. At -35 minutes (1940 EST) a hold was called since the RF No. 2 battery indicated a redline condition on the RF panel. The count was recycled to -70 minutes and all three telemetry batteries were replaced to avoid redline later for elapsed time after activation. Checks on the removed batteries indicated proper operation. The RF panel was then checked but also indicated proper panel operation. The new replacement batteries checked out satisfactorily upon installation and no further difficulties in this area were encountered. The count was resumed at 2141 EST after a hold time of 121 minutes.

2. At -7 minutes (2244 EST) to investigate variation of deviation on RF No. 1. The count was recycled to -35 minutes and LO2 detanking was started. The count was recycled to -45 minutes at 2302 EST. After completion of LO2 detanking the RF No. 2 canister was changed in an attempt to eliminate the deviation problem on RF No. 1. All three RF systems checked out satisfactorily. The countdown was resumed at 0008 EST on 11 March 1961 at -45 minutes. The test was terminated at 0023 EST when loss of deviation on RF No. 1 was again reported and there was insufficient time to correct the problem before the 0100 EST cutoff time.

Post-test investigation revealed loss of RF No. 1 deviation upon going from Stage I to Stage II pressurization and starting LO2 tanking.

EST	Countdown Time	Countdown Procedure	Event
1745	T-150	T-150	Countdown Started.
1745	T-150	T-150	Nose Cone Securing Completed.
1745	T-150	T-150	GAP Test Preparation Started.
1751	T-144	T-144	Readiness Callouts by Flight Control.
1754	T-141	T-144	GAP Test Started.
1800	T-135	T-144	GAP Test Completed Satisfactorily.

EST	Countdown Time	Countdown Procedure	Event
1801	T-134	T-144	Telemetry Internal Power Check.
1809	T-126	T-135	Range Safety Command Tests Started.
1817	T-118	T-125	Range Safety Command Tests Completed.
1818	T-117	T-125	Started Electrical Connection of Red Destruct Box.
1823	T-112	T-120	Finished Electrical Connection of Red Destruct Box.
1830	T-105	T-90	AIGS Ready for Removal of Landlines.
1835	T-100	T-100	Flight Control System Test Finished.
1840	T-94	T-95	Service Tower Removal and Securing Started.
1850	T-85	T-85	Helium Pressure Storage Preparation Started.
1900	T-75	T-100	Nose Cone Telemetry and Beacon "ON".
1903	T-72	T-75	Computer DSC Test Started.
1907	T-68	T-100	Flight Control System Test Finished.
1909	T-66	T-65	Start Landline Calibrations.
1912	T-63	T-65	Computer DSC Test Completed.
1914	T-61	T-70	Tower is Secured.
1917	T-58	T-75	Helium Storage Preparation Completed.
1919	T-56	T-70	Helium Storage Started.
1920	T-55	T-55	Gap Test Preparation Started.
1921	T-54	T-55	Readiness Callouts By Flight Control.
1922	T-53	T-52	Gap Test Started.
1925	T-50	T-50	Secure GN2 Topping Gear.

EST	Countdown Time	Countdown Procedure	Event
1928	T-47	T-52	GAP Test Completed Satisfactorily.
1930	T-45	T-45	LO2 Tanking Preparation Started.
1938	T-37	T-35	LO2 Tanking Started.
1940	T-35H	G-35H	-35 Minutes and Holding to Replace Telemetry Battery.
1945	T-35H	T-35H	Recycle Count to -70 Minutes and Estimate One Hour Hold.
2020	T-70H	T-70H	All Three Telemetry Batteries are out.
2038	T-70H	T-70H	All Three Original Telemetry Batteries Read Normal Voltage After Being Removed From The Missile.
2055	T-70H	T-70H	RF Panel Check Showed no Voltage Indication from Test Battery on Test Stand.
2100	T-70H	T-70H	RF Panel Check with Original Battery Showed Normal Indication on the Panel.
2103	T-70H	T-70H	Proceed with Installation of New Batteries.
2122	T-70H	T-70H	Activate Telemetry Batteries.
2125	T-70H	T-70H	Voltages are All Normal.
2126	T-70H	T-70H	Begin Tower Removal.
2127	T-70H	T-70H	GAP Test Will Be Run Again.
2131	T-70H	T-70H	Start LN2 Chilldown.
2131	T-70H	T-70H	Helium Storage Preparation Started.
2140	T-70H	T-70H	Helium Storage Preparations Completed.
2141	T-70	T-70	-70 Minutes and Counting.

EST	Countdown Time	Countdown Procedure	Event
2141	T-70	T-5	GAP Test Started.
2145	T-66	T-70	Start Helium Storage.
2146	T-65	T-65	Start Landline Calibrations.
2148	T-63	T-52	GAP Test Completed Satisfactorily.
2202	T-49	T-50	Landline Calibrations are Completed.
2206	T-45	T-45	LO2 Tanking Preparation Started.
2212	T-39	T-35	LO2 Tanking Started.
2221	T-30	T-30	Flight Control System Final Checks Started.
2227	T-24	T-22	Final RSC Command Checks Started.
2229	T-22	T-35	Azusa Checks Started.
2230	T-21	T-35	Retract Holddown Hooks.
2231	T-20	T-20	Start Final Telemetry Warmup.
2242	T-9	T-10	Telemetry/RSC AGC Check Started.
2244	T-7H	T-7H	-7 Minutes and Holding to Investigate RF No. 1.
2246	T-7H	T-7H	RF No. 1 Deviation Normal with Just RF No. 3 On.
2246	T-7H	T-7H	RF No. 1 Deviation Drops When RF No. 2 is Turned On.
2247	T-7H	T-7H	Final RSC Checks Completed.
2253	T-7H	T-7H	Standby to Detank LO2.
2253	T-7H	T-7H	Detanking LO2.
2258	T-35H	T-35H	Recycle to -35 Minutes and Holding.

EST	Countdown Time	Countdown Procedure	Event
2300	T-35H	T-35H	Azusa Turned "OFF".
2302	T-45H	T-45H	Recycled to -45 Minutes and Holding.
2320	T-45H	T-45H	Will Replace RF No. 2.
2335	T-45H	T-45H	Tower Coming In.
2340	T-45H	T-45H	Tower Is In Place.
2344	T-45H	T-45H	RF No. 2 Can is Off.
2347	T-45H	T-45H	New RF No. 2 Can is in Place.
2351	T-45H	T-45H	Securing the Pods.
2354	T-45H	T-45H	Tower Removal Started.
2400	T-45H	T-45H	LO2 Tanking Preparation Started.
0008	T-45	T-45	-45 Minutes and Counting.
0011	T-42	T-40	LO2 Tanking Preparation Completed.
0017	T-36	T-35	LO2 Tanking Started.
0021	T-32	---	Deviation on RF No. 1 - Zero.
0023	T-30	---	Test Terminated Due to Problem With RF No. 1.

A brief compilation of significant difficulties encountered during system preparation and testing at AMR follows.

Propulsion System

The propulsion system configuration was changed as follows:

1. PU mechanical stop and the LO2 self-referencing regulator settings were changed per GMA 7898 A.

2. The hydraulic control package mount bracket was strengthened by adding welded gussets.

3. The control package accumulator mount was replaced with a stronger mount per GMA 6364.

4. Clips were welded on the sustainer aspirator to prevent the sustainer boot from slipping forward during flight per GMA 6265.

The No. 2 vernier engine had to be changed because of excessive hydraulic oil leakage past the gimbal shaft seals. The replacement vernier was not modified to the latest configuration in that the vernier LO2 bleed extension index hole was not drilled, and the conduit bracket was not installed. The replacement engine was modified before installation.

The vernier LO2 supply flex hose was changed on X-2 Day in accordance with an AMR Design Bulletin. This change is an interim fix until a replacement part is certified. The engine flush operation was delayed because the reel -3 solenoid valve developed an internal short. The valve was IR'd and replaced. The replacement valve also developed an internal short. The pneumatic test cart was used to supply the reel-3 purge to complete the engine flush.

The Vernier No. 2 engine fuel tube and the Vernier No. 1 engine LO2 tube were found to interfere with the booster thrust structure at Station 1135. The fiberglass fairings were removed from the hot stiffeners to give approximately 1/8 inch clearance.

The NAA accumulator mounting bracket showed signs of deformation when the clamp toggle bolts were torqued to 90 in. lbs. per GMA 6364. The bracket was changed and GMA 7899 was written to torque the bolts to only 70-75 in. lbs.

Hydraulic Systems

The B2 hydraulic accumulator precharge was lost overnight The accumulator was recharged and charge lines leak checked The precharge again decayed to zero within 6 hours. The accumulator was IR'd and replaced.

The vernier solo hydraulic accumulator precharge showed a slow decay of about 50 percent of the original precharge over a 12 hour period. The charge system was leak checked several times without finding evidence of leakage. The replacement part was BOI'd from Missile 12E.

The B2 hydraulic accumulator, the vernier solo accumulator, and the Vernier No. 2 engine changes were made before completion of the airborne hydraulic fill and bleed.

Airframe

The booster separation latches would not rotate freely under their own weight. An insufficient gap existed between the sides of the latch bracket and the arm. The paint and some material was removed to allow free rotation and some side motion.

One hinge that supports the B1 SPGG access door was broken during preparation for propellant tanking where the V2 work platform was raised. A substitute hinge was installed per IR rework.

A large dent was observed on the missile LO2 tank dome. The tank pressure was 2 psig. IR 588984 was dispositioned as being acceptable to Design Engineering.

A latch on Pod No. 1 door was found broken and was replaced per IR 568645.

Re-entry Vehicle

Item	Test	FTI No.	Date Completed
1	Receiving Inspection	24145	12/9/60
2	Arming and Fuzing	23846A	3/2/61
3	Spacer Spin and Separation	23846A	3/3/61

Item	Test	FTI No.	Date Completed
4	FAC Test (Spacer Only)	23850D	3/6/61
5	Instrumentation Subsystem	23845D	3/7/61
6	Telemetry Antennas	23846A	3/8/61
7	Sensor Stimulation	23845D	3/8/61
8	Signal Data Converter	23845D	3/8/61
9	System Confidence Test	23847B	3/9/61
10	Seal Test	23893	3/9/61
11	Weight and C. G.	23869A	3/9/61
12	Final Acceptance	23848B	3/9/61
13	X-1 Day	23852B	3/9/61
14	Countdown	23853C	3/10/61
15	Countdown	23853C	3/13/61

Flight Control System

The sustainer engine alignment check showed sustainer yaw to be out of the tolerance specified in the procedure. The sustainer yaw actuator was removed and the length adjusted per San Diego instructions until the specifications outlined in procedure 27-90332-1, dated 24 January 1961, were met.

During booster frequency response at 0.25 cps, a distinct kick on the B1 engine in the pitch channel was noted. Preliminary investigation indicated a malfunction of the actuator and this component was replaced; however, this did not eliminate the problem. A thorough investigation resulted in replacing an isolation amplifier which was causing an oscillation in the feedback loop. The amplifier change eliminated the problem.

Inertial Guidance System

When performing the periodic validation procedure, the Inductosyn No. 1 loop was found to be inoperative. Investigation revealed a loose connection at Pin V of the platform plug 302U1 P 603. This was repaired.

During the FACT countdown, fogging of the missile vertical line of sight port in the Arma platform was experienced resulting in a loss of optics. TVA 25864 was written to remove the bellows assembly which is normally installed between the line of sight port and the pod cover access port. No further fogging problems were encountered.

Telemetry System

On 7 March 1961, RF 2, S/N 0132 was removed because of an open segment 19 on Channel E. S/N 9V11 was used as the replacement.

On 10 March 1961, during launch attempt countdown, the RF 2 battery was replaced because B+ had dropped below open circuit redline value. When the battery was removed, the output had dropped to zero as indicated on the RF panel meter.

On 10 March 1961, during the launch attempt countdown, RF 2, S/N 9V11 was replaced because of its suspected cause of low subcarrier deviation on RF 1 due to spurious frequencies generated. Installed RF 2, S/N 0132 which did not eliminate the problem. Because of this problem, the launch operation was cancelled.

On 11 March 1961, the specific problem encountered on 10 March was determined to be a drop in subcarrier deviation on RF 1 when Stage II pressure was applied to the fuel tank. Investigation revealed that this problem was due to poor RF bonding on the Pod I antenna and the upper Pod I fairing. This bonding problem was corrected and a test was run by applying Stage II tank pressure and tanking a small quantity of LO2 to verify proper telemetry operation.

Missile Electrical System

During hangar checkout of Missile 13E, all harnesses were inspected and found to contain wires having splices incapable of withstanding a five pound minimum test pull.

Harness Number	IR Number	Discrepancies
27-61820-827	609421	4 defective splices
27-61829-819	589432	4 defective splices
27-61820-827	589468	1 defective splice
27-62726-849	589472	1 defective splice
27-62734-803	586926	2 defective splices
27-62732-829	586925	1 defective splice

The following is a list of other discrepancies found in the missile harnesses during hangar checkout.

27-62731-831	589471	7 wires with cut insulation
27-61824-819	589470	1 open circuit
27-61823-889	568914	1 crushed wire
27-61829-819	587154	1 open circuit
27-61829-819	587156	1 crushed wire

During an extended hold due to weather conditions in the Countdown Operations of 13 March 1961, the missile main battery dropped to redline value of 35.5 volts. The battery was then subjected to a 45 second load test during which the voltage output was 29.0 volts. Fifteen minutes after this load test the battery voltage read 34.5 volts. Since the load voltage and the voltage 15 minutes after the load test were well above the redline values, the battery was considered acceptable for flight.

RF Systems and Strobe Light

Missile 13E was received at the complex with the Range Safety Command, Azusa, and the Strobe Light System installed. Subsequent testing on the complex indicated and insured proper operation of all system components involved. All results of testing were as expected and satisfactory.

Mod III E Instrumentation Beacon

No significant problems were encountered during routine testing performed on Missile 13E.

Propellant System

A Teflon Seal in the LO2 slug unit was discovered leaking following Missile 13E launch. This is the third failure of this seal (27-295/8-7) at Complex 13. This seal is used in two locations.

An investigation of the slug unit GN2 Filter, resulting from a reported failure at ERB, revealed a structural failure of the filter element. Traces of the elements missing sections were recovered from the diffuser element in the slug LO2 tank. The diffuser was intact.

During the LO2 tanking test, a failed V-belt on the pump LC varidrive assembly was replaced. The belt appeared to have worn out since the fabric core had deteriorated. The belt had been in service 1 1/2 years (minimum) at the time of failure.

During the launch countdown, the pump LC varidrive V-belt again failed. Post-test investigation revealed a failed pump seal on LC, exposing the varidrive assembly to a LO2 environment. This environment is believed to be the primary cause of the failure. A contributing factor may have been the long shelf time (five of the six spare belts have been in spares since 1958) of the item. The effective shelf life of the rubber and fabric belt in a hot, humid environment is being investigated. The missile was tanked using a storage tank pressure of 40 psig to compensate for the failure.

Propellant Utilization System

The following problems were encountered during systems checkout:

During performance of ATP U-102/B, on matched PU set No. 628, the sustainer fuel valve could not be moved from the nominal position while in PU control. The set was IR'd and returned to San Diego for a re-work. Since no back-up was available at AMR, matched set No. 614 was BOI'd from Missile 12E on Complex 11. This set was checked out and adjusted per ATP U-1029B for Missile 13E with satisfactory results.

Due to concern in San Diego over the performance of the PU system on Missile 9E, it was decided to re-check the valve angles per ATP U-1029B. During this check on set No. 614, the PU unit would not take control of the valve, possibly due to a slight deviation from procedure. This deviation occurred when pressures were brought up prior to energizing the sustainer ignition control switch. By energizing the switch under these conditions, the PU valve cycled from open to partially closed several times until the switch was de-energized. Pressures were reduced and brought up again per procedure with a slight increase in control sensing pressure. The valve then assumed PU control and the angles were re-adjusted due to a 0.75 degree shift in nominal position.

Set No. 614 was sent to lab for a 13 point check following the launch attempt and two pressurization checks. This set was damaged while in the lab and set No. 620 was installed on the missile for flight with a controller previously adjusted per ATP-U-1029B on No. 614 assembly. Set No. 614 was then repaired and returned to the complex for back-up on Missile 13E.

Pneumatic System

While performing leak checks in the high pressure helium system, a leak was detected at the LO2 regulator inlet. When the "B" nut was removed from the reducer in the LO2 regulator, it was discovered that the dural reducer threads were damaged. There was no replacement for the dural reducer. A TVA was written to install an available stainless steel reducer, the only difference in the two reducers being the material from which they were made.

During initial run of LN2 shroud cold check, no chilldown of the Quad I/II shroud was observed. Investigation revealed that the orificed union at the Quad I/II shroud inlet was incorrect. The orifice was redrilled to the intended diameter and a successful chill test completed without further incident.

APPENDIX

FLUID CHEMICAL ANALYSIS

Liquid Oxygen	Units	Sample	Specifications
Purity	Percent	99.75	99.5 Minimum
Hydrocarbons			
Methane	ppm	None	75.0 Total Max.
Acetylene		None	0.5 Max.
Carbon Dioxide		2.5	
Particle Count			
50 - 175	Microns	20	No solid particles greater than 175 microns. (Fibers not acceptable.)
175/	Microns	1	
Fibers		18	

This item is nonacceptable.

Fuel RP-1			
Initial Boiling	°F	360	Report
10 Percent	°F	389	364-410
50 Percent	°F	418	Report
90 Percent	°F	450	Report
End Point	°F	477	525 Maximum
Residue	Percent	0.75	1.5 Maximum
Loss	Percent	0.75	1.5 Maximum
Flash Point	°F	143	110 Minimum
Gravity	°API	43.6	42.0 to 45.0
Particle Count			
10 - 20	Microns	6500	No solid particles greater than 175 microns. (Fibers not acceptable.)
20 - 40	Microns	2880	
40 - 80	Microns	180	
175 /	Microns	2	
Fibers		8	

This item is nonacceptable.

Gaseous Helium	Units	Sample	Specifications
Purity	Percent	99.9/	99.9/ Minimum
Hydrocarbons	ppm	None	75.0 Total Max.

This item is acceptable.

Gaseous Nitrogen			
Purity	Percent	99.4	99.5 Minimum
Hydrocarbons	ppm	None	75.0 Total Max.

This item is nonacceptable.

Lubricating Oil			
Viscosity @ 100°F	Centistokes	12.8	23.0 to 34.0
Viscosity @ 210°F	Centistokes	3.3	
Flash Point	°F	454	280.0 Minimum
Color		Pass	
Viscosity Index		154.6	80.0 Minimum
Appearance		Pass	

This item is acceptable.

Trichloroethylene			
Appearance		Pass	Clear and Free.
Color		Pass	Nor red, blue, green, or purple dyed.
Odor		Pass	Normal
Specific Gravity	@68°/68°F	1.468	1.454 to 1.476
Distillation	°F	86.7	85.0 to 91.3
Water Content	@/14.0°F	Pass	Cloudless
Non-volatile	Percent	0.0007	0.002 Maximum

This item is acceptable.

Hydraulic Fluid - Sustainer	Units	Sample	Specifications
Flash Point	°F	212	200.0 Minimum
Color		Pass	Report
Viscosity	Centistokes	8.3	10.0 Minimum
Water by Distillation	Percent	Cannot be meas. by Spec. Meth.	
Dye		Pass	
Hydraulic Fluid - Booster			
Flash Point	°F	213	200.0 Minimum
Color		Pass	Report
Viscosity	Centistokes	8.2	10.0 Minimum
Water by Distillation	Percent	Cannot be meas. by Spec. Meth.	
Dye		Pass	
Particle Count - Sustainer			
10 - 25	Microns	2760	5500 Maximum
26 - 50	Microns	540	1200 Maximum
51 - 100	Microns	30	300 Maximum
Over 100	Microns	2	20 Maximum
Fibers		5	20 Maximum
Particle Count - Booster			
10 - 25	Microns	4800	5500 Maximum
26 - 50	Microns	720	1200 Maximum
51 - 100	Microns	60	300 Maximum
Over 100	Microns	5	20 Maximum
Fibers		10	20 Maximum

These items are nonacceptable.

REFERENCE DOCUMENTS

Flight Test Plan - Missile No. 13E	AE60-0436
Flight Test Program - SM-65 Series E, R & D Missiles	AZC-27-005
Detailed Test Objectives (AFBMD/STL)	STL/OR-61-0000-19001
Flight Test Directive (FTWG)	AA 60-0142

Additional reports which may be referenced for further information regarding this missile are listed below:

Reports	Approximate Issue Date (time after test)
Convair - Astronautics, San Diego, Calif.	
Flight Test Evaluation Report	14 Days
AFBMD/STL, Inglewood, Calif.	
Flight Summary Report	8-12 Weeks
ARMA, CCO	
CCO Quick Look Report	7-10 Days
American Bosch ARMA Co., Garden City, N. Y.	
Flight Test Evaluation Report	30 Days
General Electric, Philadelphia, Pa.	
Evaluation Report	30 Days
General Electric, Syracuse, N. Y.	
Evaluation Report of Mod III Instrumentation System with Missile 13E	6-10 Weeks

SERIAL NUMBERS OF SYSTEMS COMPONENTS

Azusa Transponder, Serial No. 731-0051

Re-entry Vehicle, Serial No. 3-1B-230

Range Safety Command System

Range Safety Command Receiver No. 1, Serial No. AF-60-53
Range Safety Command Receiver No. 2, Serial No. AF-60-54
Range Safety Command Receiver No. 1, Battery Serial No. 010-0281
Range Safety Command Receiver No. 2, Battery Serial No. 010-0306
Range Safety Command Power and Signal Control Unit, Serial No. 007-0024

Propulsion System

Sustainer, Serial No. 222714
Booster No. 1, Serial No. 112721
Booster No. 2, Serial No. 112720
Vernier No. 1, Serial No. 332721
Vernier No. 2, Serial No. 3327

Electrical System

Missile Main Battery, Serial No. 907-006
Inverter, Serial No. 002-0028
Power Changeover Switch, Serial No. 007-0055

Mod III E Range Safety and Instrumentation System

Rate Beacon, Serial No. 6E8015
Pulse Beacon, Serial No. 6E1019

Telemetry System

Telemeter RF No. 1, Serial No. 0131
Telemeter RF No. 2, Serial No. 0132
Telemeter RF No. 3, Serial No. 9X24
Telemeter RF No. 1, Battery, Serial No. 101-0523
Telemeter RF No. 2, Battery, Serial No. 001-0088
Telemeter RF No. 3, Battery, Serial No. 101-0524
Accessory Package, Serial No. 009-0010

Flight Control System

Gyro Canister, Serial No. 24
Filter - Servo Amplifier Canister, Serial No. 28
Programmer, Serial No. 16

Propellant Utilization System

Matched Set, Serial No. 620

Pneumatics System

LO2 Tank Pressure Regulator, Mfg. Stratos, Serial No. 011-0010
Fuel Tank Pressure Regulator, Mfg. Stratos, Serial No. 011-0008

Inertial Guidance System

Platform, Serial No. 7210046
Control, Serial No. 7220075
Computer, Serial No. 7230029
Analog Signal Converter, Serial No. 7150038
Digital Signal Converter, Serial No. 7140045

Optical Beacon System

Unit, Serial No. 008-0025
Battery, Serial No. 001-0015

SIGNIFICANT DATES DURING TESTING OF "A" SERIES FLIGHT MISSILES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
4A	12-8-56	14	3-22-57	6-3-57	6-11-57	895	Engine shutdown after 29.9 seconds of flight. Missile destroyed at 50.1 seconds.
6A	4-4-57	14	8-2-57	9-20-57	9-25-57	1422	Engine shutdown after 47.7 seconds of flight. Missile destroyed at 74 seconds.
12A	11-1-57	14	11-20-57	12-11-57	12-17-57	2148	Successful flight. Impacted approximately 490 nm downrange.
10A	7-18-57	12	9-27-57 10-27-57 11-6-57	*11-27-57 **12-10-57 1-4-58	1-10-58	10	Successful flight. Impacted approximately 542 nm downrange.
13A	12-4-57	14	1-17-58	***1-31-58	2-7-58	222	Engine shutdown prematurely after 117.8 seconds of flight due to flight control system failure. Missile broke up at 167 seconds.
11A	12-28-57	12	1-25-58	2-8-58	2-20-58	449	Engine shutdown prematurely after 124 seconds of flight due to flight control system failure. Missile broke up at 126.5 seconds.
15A	1-6-58	14	2-26-58	3-22-58	4-5-58	634	Engine shutdown prematurely after 105 seconds of flight due to B1 turbopump failure. Missile remained intact and impacted approximately 200 miles downrange.
17A	2-5-58	12	3-17-58	****4-18-58 5-22-58	6-3-58	1261	Successful flight. Impacted approximately 480 nm downrange.

* Premature cutoff at 8 seconds. Both booster chambers damaged, necessitating replacement.

** Full duration, but damaged B1 chamber, necessitating replacement.

*** FRF terminated prematurely, but considered satisfactory.

**** Prematurely terminated due to APS shutdown.

SIGNIFICANT DATES DURING TESTING OF "B" SERIES FLIGHT MISSILES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
3B	4-12-58	11	5-29-58	*6-23-58 **6-27-58 7-8-58	***7-12-58 7-19-59	1564	Missile broke up after 45 seconds of flight due to failure of the yaw rate gyro.
4B	5-31-58	13	6-13-58	7-15-58	8-2-58	1382	Successful flight. Impacted approximately 2345 nm downrange.
5B	5-30-58	11	7-22-58	8-20-58	8-28-58	1383	Successful flight. Impacted approximately 2853 nm downrange. First completely closed loop guidance system flight.
8B	7-31-58	14	8-4-58	9-6-58	9-14-58	1511	Successful flight. Impacted approximately 3151 nm downrange.
6B	7-17-58	13	8-14-58	9-10-58	9-18-58	1512	B1 turbopump failed at 80.8 seconds after liftoff. Missile exploded two seconds later.
9B	8-7-58	11	9-12-58 ##9-30-58	#10-4-58 ###10-24-58 ####10-27-58	11-17-58	1513	Depletion of fuel supply caused simultaneous premature sustainer and vernier shutdown. Missile impacted 800 to 900 nm short of intended impact point. First flight of modified booster turbopumps.
12B	9-4-58	14	11-8-58	11-24-58	11-28-58	1730	Successful flight. Impacted approximately 5506 nm downrange.
10B	10-22-58	11	11-20-58	****12-9-58 ****12-10-58 12-12-58	12-18-58	1729	Successful flight. Missile placed into orbit.
13B	12-4-58	14	12-5-58	12-22-58	1-15-59	30	Flight prematurely terminated due to unexplained difficulties starting at 100 seconds after liftoff. Missile impacted 170 nm downrange. No telemetry system was aboard this missile.
11B	8-22-58	11	12-23-58	1-20-59	2-4-59	29	Successful flight. Impacted approximately 3122 nm downrange.

* Automatic cutoff initiated by sustainer overspeed/underspeed trip 1.96 seconds after BGG links break.

** Automatic cutoff initiated by sustainer overspeed/underspeed trip 1.08 seconds after BGG links break.

*** Prematurely terminated by an automatic cutoff 4.98 seconds after BGG links break.

**** Vernier ignition only.

\# Manual cutoff at 6.69 seconds.

After installation of "C" Series power pack in Hangar "J".

Automatic cutoff initiated by sustainer overspeed/underspeed trip 1.0 seconds after BGG links break.

Full duration, but engine compartment fire delayed schedule approximately 10 days.

SIGNIFICANT DATES DURING TESTING OF "C" SERIES FLIGHT MISSILES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
3C	10-31-58	12	11-4-58 *11-25-58	12-17-58	12-23-58	2501	Successful flight. Impacted approximately 3803 nm downrange.
4C	11-9-58	12	1-6-59	1-19-59	1-27-59	10	Although impact was close to intended point, the guidance system did not function.
5C	1-31-59	12	2-4-59	None	2-20-59	251	Missile exploded at 174 seconds due to a malfunction at staging. Probable cause was improper operation of the fuel staging valve.
7C	2-12-59	12	2-23-59	None	3-18-59	761	Booster engine shutdown prematurely at 131 seconds of flight. Missile was unstable for remainder of flight.
8C	5-7-59	12	5-11-59	**5-22-59 **7-9-59	#7-15-59 7-21-59	2103	Successful flight. Impacted in target area 4385 nm downrange. RVX-2 Re-entry Vehicle recovered.
11C	7-15-59	12	7-25-59	8-14-59	8-24-59	2121	Successful flight. Impacted almost 5 miles long in MILS net due to residual thrust after vernier cutoff. Re-entry vehicle was recovered.

* After power pack modification.

** Two successful Flight Readiness Firings performed.

Ignition achieved twice. Manual cutoff for 1st. attempt in vernier ignition phase. Second attempt terminated by release timer.

SIGNIFICANT DATES DURING TESTING OF ATLAS SERIES FLIGHT MISSILES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
3D	2-25-59	13	2-27-59	3-27-59	4-14-59	1002	Booster section exploded 27 seconds after liftoff due to failure of airborne LO2 fill and drain valve to close. Missile destroyed at 37 seconds.
7D	3-20-59	14	4-13-59	5-8-59	*5-15-59 5-18-59	1754	Missile exploded at 65 seconds due to improper launcher operation which resulted in loss of fuel tank pressure.
5D	3-8-59	13	4-28-59	5-15-59	6-6-59	1753	Missile exploded at 160 seconds due to a malfunction at staging. Probable cause was improper operation of the fuel staging valve.
11D	4-10-59	11	5-11-59	**7-14-59 7-22-59	7-28-59	2002	Successful flight. Impacted 4384 nm downrange less than 1/2 mile from target in MILS net.
14D	5-7-59	13	6-10-59	7-28-59	8-11-59	2003	Successful flight. Impacted in MILS net less than 1 mile from target.
17D	5-27-59	13	8-17-59	9-9-59	9-16-59	2106	Successful flight. Impacted 2 miles short of target in MILS net due to failure of vernier sol[illegible]ydraulic package.
18D	5-27-59	11	9-2-59	None	10-6-59	2120	Successful flight. Impacted in MILS net less than 1/2 mile from target.
22D	8-26-59	13	9-21-59	None	10-9-59	3505	Successful flight. Impacted in MILS net less than 1 1/2 miles from target.
26D	9-18-59	11	10-8-59	None	10-29-59	2344	Due to malfunction of V2 engine at staging, impacted approximately 14 miles short of target point.
28D	9-18-59	13	10-14-59	None	11-4-59	4203	Unsuccessful. A/B IP failure prevented Station 5 IP system from acquiring the missile. Range safety cutoff caused R/V to impact approximately 260 miles short of target.
15D	5-9-59	11 14 13	7-11-59 9-23-59 11-7-59	None	11-24-59	2105	Successful although re-entry vehicle did not seperate. Impacted in MILS net.
31D	10-10-59	13	11-28-59	None	12-8-59	4205	Successful flight. Impacted 1/2 mile from target in MILS net.

SIGNIFICANT DATES DURING TESTING OF "D" SERIES FLIGHT MISSILES AT AMR (Cont'd)

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
40D	11-20-59	13	12-10-59	None	12-18-59	16	Successful flight. Delivered a Mk-2 Re-entry Vehicle within 3 nm of target over a 5500 nm range.
43D	12-8-59	13	12-22-59	None	1-6-60	32	Successful flight. Delivered a Mk-3 Re-entry Vehicle within 3 miles of target over a 5500 nm range.
44D	12-17-60	13	1-11-60	None	1-26-60	54	Successful flight. RVX4-A2 Re-entry Vehicle impacted approximately 1/2 mile from target in MILS net.
49D	1-5-60	13	1-28-60	None	2-11-60	320	Successful flight. Mk-3 Re-entry Vehicle impacted less than 1 1/2 nm from target over a 5500 nm range.
42D	12-5-59	11	12-21-59	#2-4-60 2-22-60	##3-4-60 3-8-60	17	Successful flight. First missile to use all-inertial guidance system open loop.
51D	1-29-60	13	2-15-60	None	3-10-60	775	Destroyed by fire and explosion immediately after liftoff.
48D	2-19-60	11	3-10-60	None	4-7-60	301	Destroyed in the stand by fire and explosion during a launch attempt.
56D	3-3-60	12	4-11-60	None	###5-12-60 5-20-60	1885	Successful flight. Delivered Mk-3 Re-entry Vehicle within 4 nm of target over an extended range of 7859 nm.
54D	2-25-60	11	5-13-60	None	6-11-60	615	Successful flight. Delivered Mk-3 Re-entry Vehicle 4306 nm downrange within 2.2 nm of target. First flight with AIG system providing active guidance functions.
62D	4-19-60	14	5-26-60	None	6-22-60	801	Impacted approximately 18 nm long due to failure of the vernier engines to shutdown when the guidance cutoff discrete was received.
27D	5-27-60	12	6-4-60	None	6-27-60	1002	Successful flight. Impacted within 1 nm of target in MILS net 4388 nm downrange.
60D	4-5-60	11	6-14-60	None	7-2-60	803	Inadvertent pressurizations of the engine tanks caused premature depletion of control helium. Re-entry vehicle impacted 40 nm short.
32D	6-22-60	12	7-1-60	None	####8-2-60 8-9-60	1003	Successful flight. Impacted within 4 nm of target in South Atlantic Ocean over the intermediate range of 6350 nm.

SIGNIFICANT DATES DURING TESTING OF "D" SERIES FLIGHT MISSILES AT AMR (Cont'd)

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
66D	6-14-60	11	7-7-60	None	8-12-60	1004	Successfully impacted re-entry vehicle within 2 nm of target. First Atlas to use AIG system with impact programmed for Station 12 MILS net.
76D	7-6-60	11	8-15-60	None	9-16-60	2817	Successfully placed RVX-2A Re-entry Vehicle within 5 nm of target. Second Atlas to use AIG System with impact in Station 12 MILS net.
79D	7-13-60	14	8-26-60	None	***9-15-60 9-19-60	802	Successful flight. Second Atlas to deliver a Mark 3 Re-entry Vehicle to target over an extended range of 7863 nm.
71D	8-19-60	11	9-26-60	None	10-13-60	1502	Successful flight. Impacted within 2 nm of target 4387 nm downrange. Last D-AIG Missile to be flight tested. RVX-2A Re-entry Vehicle recovered.
55D	2-27-60	12	3-7-60 5-24-60 10-3-60	None	10-22-60	613	Successful flight. Impacted within 1 nm of target 4350 nm downrange. The missile was flown without insulation and insulation bulkhead at the intermediate bulkhead with no adverse results.
83D	10-6-60	12	10-27-60	None	11-15-60	3503	Successful flight. Impacted less than 1 nm from target 4388 nm downrange. Data cassette recovered.
90D	12-14-60	12	12-20-60	None	1-23-61	3505	Successful flight. Last of "D" Series Weapon System flights. Impacted Mk-3 Mod 1B Re-entry Vehicle within 1/2 nm of target 4394 nm downrange.

* Launch aborted due to faulty release time, which initiated automatic cutoff.

** Test terminated by sustainer rough combustion cutoff circuitry.

*** Launch aborted 5.45 seconds after sustainer flight lockin because no release signal was generated.

\# Rerun due to Guidance System difficulties.

\## Engine cutoff prior to release due to erroneous callout in blockhouse.

\### Terminated by erroneous output from B2 primary RCC accelerometer.

\#### Terminated 1.53 seconds after sustainer flight lockin by the sustainer RCC system.

SIGNIFICANT DATES DURING TESTING OF "E" SERIES FLIGHT MISSILES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
3E	5-19-60	13	7-29-60	*9-23-60 10-3-60	10-11-60	1502	Malfunction in sustainer hydraulic system caused loss of missile after staging.
4E	7-15-60	13	10-21-60	None	11-29-60	2800	Sustainer hydraulic pressure was lost at 41 seconds and caused missile to become unstable at booster cutoff. Sustainer thrust was lost at about 150 seconds.
8E	10-25-60	13	12-5-60	None	1-24-61	3504	Missile stability was not maintained after 161.8 seconds due to loss of engine servo control in flight control system. Sustainer engine shutdown at 249 seconds.
9E	11-11-60	13	1-30-61	None	2-24-61	3803	Successful flight. Impacted Mark 3 Mod II B Re-entry Vehicle within 600 yds. of aim point.

* B2 lube oil pump shaft sheared. Test duration 16 seconds.

SIGNIFICANT DATES DURING TESTING OF MERCURY/ATLAS VEHICLES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
10D	4-10-59	14	6-2-59 *7-22-59	9-3-59	9-9-59	2119	Successful flight although booster section failed to jettison. Project Mercury Capsule recovered.
50D	5-17-60	14	6-30-60	7-21-60	7-29-60	1505	Unsuccessful. Missile apparently destroyed after 60 seconds of flight. Mercury Capsule remained intact until impact.
67D	7-8-60	14	11-4-60	11-19-60	2-21-61	419	Successful MA-2 mission. Impacted Mercury Capsule as planned. First closed loop flight for ASIS. Capsule recovered.

* Returned to hangar for booster power package replacement.

SIGNIFICANT DATES DURING TESTING OF MIDAS VEHICLES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
29D	10-10-59	14	1-18-60	None	2-26-60	304	MIDAS I Booster shot. Atlas portion of flight was successful.
45D	1-26-60	14	3-2-60	None	5-24-60	619	MIDAS II Booster shot. Atlas portion of flight completely successful.

SIGNIFICANT DATES DURING TESTING OF ATLAS/ABLE LUNAR PROBES AT AMR

Missile	Arrival	Complex	Erection	FRF	Flight	AMR Range No.	Comments
9C	4-4-59	12	4-15-59 #8-17-59	9-24-59		2944	Destroyed by fire and explosion following premature cutoff during flight readiness firing.
20D	9-10-59	14	10-19-59	None	11-26-59	4122	Atlas/Able IV Lunar Probe. Atlas portion of flight was successful. Portions of Able failed at 47 seconds.
80D	8-13-60	12	9-2-60	None	9-25-60	2801	Atlas/Able V Lunar Probe. Atlas portion of flight was successful. Second stage engine operation unsatisfactory.
91D	10-15-60	12	11-17-60	None	12-15-60	4508	Unsuccessful. Flight was terminated after 74.5 seconds when the vehicle destroyed itself.

#Erected twice due to cancellation of test and subsequent return to hangar for storage.